Air Pollution and Man's Health

Three instances of constructive community efforts toward control of atmospheric pollution buttress Doyle's contention in the preceding paper that "we shall be able to cope with the problem before a threatened saturation impels desperate action." The reports "briefed" here were given before the annual meeting of the American Industrial Hygiene Association in Los Angeles on April 23, 1953. Mr. Isaac's complete review of smoke-abatement efforts in Great Britain will appear in the Archives of Industrial Hygiene and Occupational Medicine, published by the American Medical Association. The other two are to be published in full in Modern Sanitation. Of pertinence are two earlier Public Health Reports presentations: Fogs and Deaths in London, December 1952, by John A. Scott (May 1953, p. 474) and The Detroit-Windsor Air Pollution Study (July 1952, p. 658).

In Great Britain

PHR brief

As long ago as 1257, Eleanor, Henry III's Queen, was forced to leave Nottingham because of the coal smoke. The first smoke abatement law was passed in 1273 by Edward I, who prohibited the use of coal as being prejudicial to human health. In 1306, the first smoke-abatement group was "formed" by the lords and others attending Parliament who were annoyed at the increasing smoke. As a result, a Royal Proclamation was promulgated prohibiting artificers from using coal in their furnaces. In 1307, one offender was condemned and executed for this offense.

The agitation against smoke has continued. Today, the emphasis is on using fuel efficiently so as to avoid the production of smoke rather than on the Canute-like attempt to prevent the use of coal. Though the wheel is turning full circle since, in the smokeless zones which have been established in some British cities it is an offense to use other than "smokeless" fuels, which do not include raw coal.

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Extent of the Problem

Albert Parker has estimated the sources and extent of the pollution from the combustion of coal and its products and has calculated that the damage to buildings, equipment, fabrics, and agriculture, together with the waste of fuel involved in producing smoke, cost Britain at least £50 million a year. Others have estimated the cost at double this amount, allowance being made for postwar increases of cost.

Measurement of Pollution

The systematic measurement of pollution in Britain was started about 1916 with the introduction of the deposit gauge. Since then, measurements of deposited matter, of smoke, and of sulfur dioxide have been made with the cooperation of an increasing number of local authorities and other agencies. In 1952, there were 140 cooperating agencies: governmental

groups, university departments, and research organizations, as well as local authorities.

Control by Law

Except in the smokeless zones, statute law in England does not cover the private dwelling, and, regrettably, a number of industrial processes are partly or completely exempt. Recourse may be had to common law, however, for a nuisance from any source.

The Public Health Act of 1936, and the Public Health (London) Act of 1936 are the general statutes upon which local authorities mainly rely for preventing smoke nuisance. Under them the local sanitary authority is required to inspect its district for the detection of "statutory nuisances." This inspection is conducted by appropriately qualified medical officers and sanitary inspectors.

Statutory smoke nuisances are defined as any installation for the combustion of fuel for manufacturing processes, or for steam-raising that does not prevent, so far as practicable, the emission of smoke to the atmosphere, or as a chimney which emits smoke in such quantity as to be a nuisance. The model bylaw, which is adopted by many local authorities, defines the second type of statutory smoke nuisance as one in which "black" smoke is emitted for more than 2 minutes in any period of 30 minutes. However, since the domestic chimney is excepted, and since many industries in which black smoke may be an inevitable consequence of the process used are also excepted, it has usually been found much more effective to attack this pollution along the road of fuel economy than by means of summary action under this statute. In addition, local authorities are permitted to group into "joint boards" for the control of atmospheric pollution and to expend money in research and investigation into its causes and control.

The Public Health Act of 1936 also applies to vessels in inland or coastal waters but not to vessels habitually used as seagoing ships.

Under the Railways Clauses Consolidation Act of 1845, steam locomotives must be constructed so as to consume their own smoke.

A fair number of local acts have more stringent requirements. The very considerable improvement in atmospheric conditions in a number of British cities is due, however, to the educational and advisory activities of the sanitary authorities rather than to their wielding of the statutory "big stick."

Prior Approval

It would seem that prior approval of furnaces in Britain is less effective than in the United States because nowhere is it mandatory. However, a number of cities have statutory provisions for voluntary prior approval.

The first legal provisions for prior approval were embodied in the Manchester Corporation Act of 1946. These require that no furnace shall be installed unless it is, so far as practicable, capable of being operated continuously without emitting smoke—this does not apply to single dwellings. If the detailed plans of such a furnace are submitted for prior approval and either receive approval or do not receive disapproval within 6 weeks, no action can be taken against the person installing the furnace. Before the corporation can serve a notice expressing disapproval, it must consult with the Minister of Fuel and Power. In establishing what is "so far as practicable," due account must be taken of cost and of local conditions. Although the submission of plans for prior approval is seen to be voluntary, it carries the incentive of removal of the threat of proceedings.

Smokeless Zones

Smokeless zones were first suggested in 1935. Now a well-established policy of the National Smoke Abatement Society, their wider adoption must greatly depend on the educative efforts of the society and similar groups. With the present shortage of fuel in Britain, the adoption of smokeless zones is most usefully coupled with stressing the more efficient use of fuel. The houseowner, who may be chary of the capital outlay on replacing the traditional open grate by a more efficient, and less smoky, fuel-burning appliance, can be attracted by the prospective savings in fuel costs. The cost and the shortage of smokeless fuels are major obstructions to the general adoption of smokeless zones.

Efficient Domestic Stoves

Most of the coal used domestically in 1948 (37 million tons) was burned in open grates and kitchen ranges of traditional design and low efficiency. Although about half the present domestic consumption of coal could be saved by its more efficient use, a very much smaller saving would, no doubt, be effected since the greater efficiency of the newer appliances would be used to provide greater comfort for the same fuel outlay.

Within recent years, many manufacturers have made successful efforts to design more efficient fires and stoves for domestic heating. The Fuel Research Station of the Department of Scientific and Industrial Research has tested many of these appliances, and the Minister of Health in consultation with the Minister of Fuel and Power and other Government departments has issued a list of approved appliances.

The sale of these newer and more efficient appliances has greatly increased since the end of the war. Increasing attention is being paid to improving the insulation of houses so as to conserve heat and so to reduce the amount of fuel used.

Fuel-Saving in Industry

It is in industry, perhaps, that the greatest strides have been made in the more efficient use of fuel, especially in the generation of electricity which now requires about 30 million tons of coal a year. In 1921, 1 kilowatt-hour of electricity required 3.4 pounds of coal; now, only 1.4 pounds is needed.

During the war, in order to eliminate from merchant ships the telltale smoke plumes that occurred soon after firing, the Fuel Research Station designed smoke-eliminator doors for the furnaces. These provided the extra secondary air when it was needed. This principle has now been extended to the design of smoke-eliminator doors for a number of shell-type boilers.

The Ridley Report

The recent report of the Committee on National Policy for the Use of Fuel and Power Resources (the Ridley report of 1952) is most germane to this issue of fuel efficiency and smoke abatement. It makes the following recommendations:

Development of more efficient types of open fires to burn coal more efficiently and smokelessly.

Increased use of gas for domestic heating during peak loads on electricity generation.

Expansion of the fuel-efficiency advisory service.

Financial incentives to firms installing efficient equipment for combustion.

Prior approval for industrial and commercial heating plants.

More training schemes for stokers.

Replacement of steam railway locomotives by other types.

Wider use of low-temperature carbonization for production of smokeless fuels.

More general adoption of smoke abatement bylaws under the Public Health Act of 1936.

More smokeless zones.

In Detroit

PHR brief

Detroit's present air pollution control program was started in 1947 when a committee of the Engineering Society of Detroit, at the request of the Department of Buildings and Safety Engineering, drafted a comprehensive air pollution control ordinance. Upon enactment of the ordinance, which replaced Detroit's smoke abatement ordinance, the Bureau of Smoke Inspection and Abatement was reorganized on an engineering control basis with a staff of 3 engineer administrators and supervisors; 17 air pollution inspectors; 5 office personnel; and 2 chemists, classified as industrial hygienists.

The air pollution control ordinance is enforced primarily by obtaining compliance. Court action is resorted to only for recalcitrants

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because, when a case reaches the courts, the bureau believes it has failed to "sell" the requirements of the community to the violator.

Control Alerting

Visible air pollution is controlled in Detroit by 15 district air pollution inspectors as well as by an observer for the bureau who dispatches two radio-equipped automobiles manned by air pollution inspectors. The observer watches for the sources of excessive air pollution, while they are active, from any one of several high buildings in different parts of the city. Citizen complaints are also served by the radio-equipped automobiles.

Measurements of "streetosphere" concentrations of pollutants are obtained to evaluate the need in a specific neighborhood for corrective work at a specific point source and to correlate such concentrations with various kinds of effects. Stack samples are obtained when it is necessary to evaluate air pollution emissions at the source.

Local industries and city departments operating large plants have been persuaded to engage in research and development when no technical controls for specific air pollution emissions were known. Examples of some recent and current projects are:

An intensive examination by the Chrysler Corporation of its problem of controlling dirtying particles from the continuous melt gray iron electric furnaces at its Dodge-Winfield plant.

The research by the city departments of public works and water supply into the problems of collecting dust particles from high-temperature gases at incinerator and sewage disposal plants.

The Aurora gasoline refinery's development of a neutralizer for odorous gases from a spent-caustic regenerator.

The over-fire air system of the Detroit Edison Company for reducing smoke from its large multiple-retort-stoker-fired steam generators.

Results Over 5 Years

About $14 million has been spent for installations of direct air pollution control in 5 years. This sum is for corrections required by violation notices from the bureau and does not include the large number of equipment changes made where installation permits were not necessary.

Horizontal visibility, in the absence of rain, fog, snow, or sleet, has increased measurably. Dustfall in industrial areas has been reduced.

More than 140,000 tons of fly ash a year is now being caught in fly ash collectors. Large tonnages of chemical and other dusts are also being caught. Emissions of industrial gases such as hydrogen sulfide and hydrofluorosilicic acid have been reduced.

Smoking chimneys are fewer and less frequent. A white shirt can be worn a full day. Fly ash does not accumulate along curbs and in store doorways.

Cooperative Control Efforts

The Bureau of Smoke Inspection and Abatement engages in limited research work, when no industrial sponsorship can be obtained. It freely exchanges ideas with other air pollution specialists in public agencies and in private industry. Its activities are deliberately and conscientiously integrated with related local agencies. Thus, the planning and zoning agencies are sources of reports of neighborhood problems as well as recipients of technical air pollution data and recommendations from the bureau. The bureau works continuously on improved air pollution instrumentation in cooperation with the division of industrial hygiene of the health department.

Similarly, solutions to air pollution problems which involve fire hazards are worked out cooperatively with the fire department. The local water pollution control agency is consulted about wet methods of air pollution control. Health effect determinations made by the health department guide the bureau's engineering control work.

There is still another relationship between the bureau and the Detroit Department of Health. To avoid duplication of specialized laboratory facilities, special sampling instruments and the two industrial hygienists in the bureau are stationed in the laboratory of the industrial hygiene division of the health depart-

ment. These men work under the direct supervision of the division, performing general industrial hygiene work with emphasis on air pollution sampling and analysis. When the bureau requires such measurements, the industrial hygiene division assigns men to work with the bureau's engineers and air pollution inspectors. The measurement data is then sent to the bureau for evaluation and use. Thus, in exchange the bureau is entitled to 2 man-years of air pollution measurement work per year from the industrial hygiene division.

Detroit-Windsor Study

As a byproduct of Detroit's request for abatement of the nuisance caused by smoke from ships plying the Detroit River, an international waterway, the Detroit-Windsor air pollution study of the International Joint Commission (IJC) of the United States and Canada was started. Recognizing parallel interests in various phases of the study, several local community groups in the Detroit area have contributed services, equipment, personnel, and funds.

The Detroit Edison Company erected pole supports and furnished high-volume filters. The Detroit Department of Health employs and supervises the health effects staff for the Detroit portion of the study. It also sponsored the stack-sampling course at the University of Michigan. The General Motors Corporation furnished all facilities for the joint industry conferences on the air pollution study.

The bureau pays the rent for the quarters of the United States section of the IJC Technical Advisory Board. The bureau serviced most of the high-volume filters daily and scheduled its Thomas autometer so that data could be coordinated with the IJC Technical Advisory Board's autometer. It also prepared detailed pollution source maps.

The area-wide Detroit-Windsor study will determine valid correlations between air pollutant concentrations and the effects on vegetation, corrosion, soiling, visibility, and health detriment. Already under way are a vegetation effects study and a pilot field study of health effects of urban air pollution in both Detroit and Windsor.

In Los Angeles

PHR brief

Comprehensive investigations on the causes and effects of air contaminants in the Los Angeles area show that, for the present, air pollutants can be related to such effects as reduction in visibility, eye and throat irritation, damage to vegetation, and local nuisance.

The Smog Mixture

Aerosols, gases, and vapors are the principal ingredients of smog in Los Angeles County. Dusts, smoke particles, and condensed fumes are obvious pollutants—detrimental because of physical characteristics causing reduction of visibility. The atmospheric oxidation of sulfur dioxide to sulfur trioxide and the formation of sulfuric acid mist contribute to this effect. Where atmospheric conditions provide time for the oxidation of certain hydrocarbons in the air, the polymerization of the oxidation products add to the haze. Droplets of organic acids and peroxides undoubtedly exist under certain moisture and temperature conditions. These, too, result from hydrocarbon reactions in the air.

The vapor or gas phase of smog is predominantly hydrocarbon. Olefinic, branched-chain, and cyclic compounds present in gasoline vapor are readily oxidized in the presence of sunlight and oxides of nitrogen to produce gases which are eye-irritating and damaging to vegetation. Ozone, a byproduct of the photochemical reaction, further aids the oxidation and leaves a residual ozone concentration which may reach nuisance proportions in the mass of polluted air. The Los Angeles studies have shown that the presence in the air of quantities of aldehydes, organic acids, and peroxides is largely accounted for by the reactions which occur.

Samples of the air taken under intense smog conditions in Los Angeles were analyzed by acceptable methods for identifying microquan-

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tities of materials. The results are shown below:

Aerosols

Ether-soluble aerosols.	Lead.
Sulfuric acid mist.	Aluminum.
Carbon.	Calcium.
Silicon.	Iron.

Gases and Vapors [1]

Acetylene.	Methyl chloride.
Aromatics.	Nitric oxide.
Benzene.	Nitrogen dioxide
Isobutane.	Nitrous oxide.
n-butane.	*n*-pentane.
Butenes.	Phosgene.
Carbon tetrachloride.	Propane.
Ethane.	Propylene.
Ethyl benzene and/or xylene.	Sulfur dioxide.
Formic acid.	Toluene.
Methyl Cellosolve	Trichlor ethylene.

Unsaturated hydrocarbons ranging from C_3H_8 to $C_{12}H_{24}$.

Products of oxidation of the above unsaturated hydrocarbons (aldehydes, peroxides, ketones, and organic acids).

[1] In addition to normal gaseous constituents of the atmosphere.

The aerosols are listed in order of importance as they affect visibility, which has been determined by a relative pollution index.

Results of Controls

Control efforts in Los Angeles have been highly gratifying. Over 600 tons of air pollutants once discharged daily into the atmosphere are now being withheld. Industry accomplished this by spending over $12.5 million for control equipment.

Valuable sulfur is recovered by the 360-ton daily reduction of sulfur dioxide at the refineries. The amount of sulfur dioxide in the atmosphere has been reduced by 50 percent. Refineries have reduced losses of gasoline vapor, recently identified as a pollutant, by 100 tons a day.

Control equipment on metallurgical plants, in rock-crushing, asphalt paving and grinding processes, and in the food, paint, roofing, fertilizer, and soap industries is daily collecting 70 tons of dust, fumes, and other aerosols.

The efforts of the Air Pollution Control District of the County of Los Angeles to improve combustion, especially in industrial and commercial incinerators, and to eliminate smoke at burning dumps have accounted for the removal of 60 tons of smoke, 50 tons of organic acids, and 10 tons of aldehydes from the air. The dieselization program of railroads has further reduced contamination from smoke.

As a result, the number of days of intense smog has decreased; the average visibility has increased; and the concentration of many pollutants has decreased. However, the level of atmospheric pollution is still too high. No end is in sight to the rapid increase in population and the expansion of the industrial community. Estimates indicate a growth to 16,000 industrial plants and 6,000,000 persons in Los Angeles County by 1960.

New Frontiers for Study

Certain phases of the Los Angeles smog problem must still remain in the hands of the scientists and development engineers. Useful information for air pollution zoning programs is very much needed. In Los Angeles, the expansion of the community, and the critical weather conditions which prevail for 270 days each year, make it necessary to minimize the effects of the contaminants which remain after engineering controls have done the best possible job.

In order to ascertain the average wind currents, the Air Pollution Control District's meteorology department now collects wind data from over 30 stations. This study, requiring at least 3 years to complete, will be used in conjunction with the comprehensive data already obtained from air sampling and source analyses programs.

Over 6,000 tons of waste material must be disposed of daily in Los Angeles by industry, commerce, and private residents. Although improved equipment and techniques have materially reduced smoke emissions from the first two sources, domestic rubbish contributes an ever-increasing amount of atmospheric pollution. Research should be directed to the field of combustion and to the means of conserving valuable materials in rubbish. Composting certain wastes for use as fertilizer or recovery of the heat value should be aggressively explored. New ways for using and disposing of rubbish

would be a boon to every metropolitan area and a great step forward in reducing air pollution from millions of incinerators.

The physiological effects of air pollution is a virtually untouched field. Many living in industrial areas believe their health is being impaired. Controlled experiments are extremely difficult because of the relatively low concentrations of most contaminants. Where submicron dusts or fumes are involved, fundamental research has progressed to a point where some experiments can be undertaken, but years of research will be required for even preliminary answers.

The control of gasoline vapor is another major problem. Despite the amount now kept out of the air in Los Angeles, about 500 to 700 tons a day are still escaping from the processing and distribution of gasoline. Methods to correct losses should be pressed forward. Refinery processes, evaporation losses, and transfers of gasoline from tank to tank are the main control points.

The release of hydrocarbons from automobiles requires detailed study. While some preliminary research has been started in Los Angeles, much remains to be done. Evidence indicates that the exhaust from vehicles may be an item for control measures. Before any action can be taken, the contribution to general air pollution of a community, or to the street-level nuisance effect, must be clearly demonstrated.

Other projects such as the reduction of sulfur dioxide from coal- and oil-burning equipment, improved fly ash collectors and basic studies on filter media, analytical methods, and instrumentation are being undertaken by many research organizations. It is recognized that these studies will assist the control efforts of industry and government, but it is short-sighted to ignore problems which appear on the horizons of our growing communities.

Increased populations, technologic changes in industry, and the use of new products generate new community problems before the old ones are solved. A striking example in the field of air pollution control lies in the fact that techniques are not available for full protection to a community against potential radiation hazards, which could develop from the wide use of radioactive materials in industrial processes.

Public Health Service Staff Announcements

Dr. H. Van Zile Hyde, chief of the Division of International Health, Public Health Service, has been appointed by the President to serve as United States representative on the Executive Board of the World Health Organization. His appointment was confirmed by the Senate on July 20, 1953. Dr. Hyde previously held the position of United States representative from May 1948 to May 1952, which encompassed the first two terms of the United States' membership on the Board. In May 1953, the United States was elected by the Sixth World Health Assembly to its third term.

Dr. Hyde, for several years active in international health affairs, most recently as director of the health and sanitation staff, Technical Cooperation Administration, has been chief of the Division of International Health since March 1, 1953. This division, transferred from the Office of the Surgeon General to the Bureau of State Services on April 1, 1953, is also responsible for recruitment of personnel for the public health missions of foreign assistance programs, technical supervision of their work, and placement of foreign personnel for professional training.

Dr. Frederick J. Brady, international health representative in the Division of International Health, has been appointed by the President to serve as alternate representative on the WHO Executive Board.

Dr. John R. McGibony, chief of the Division of Medical and Hospital Resources of the Public Health Service since 1949, has been appointed professor of medical and hospital administration and director of the course in hospital administration in the Graduate School of Public Health of the University of Pittsburgh. A commissioned officer of the Public Health Service since 1936, Dr. McGibony contributed to the planning and development of the Hospital Survey and Construction Program. In 1946 he became assistant chief of the Division of Hospital Facilities. Prior to this appointment, he served first as hospital administrator and then as director of health for the Bureau of Indian Affairs, Department of the Interior. In recent years, Dr. McGibony was also hospital consultant to the National Security Resources Board and the Federal Civil Defense Administration.